



Pakistan food safety challenges

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Abstract

Developing societies are facing a horrible situation regarding health and economic issues due to the contamination of foods biologically, chemically, and physically. The rampantly available research on foodborne diseases, especially diarrhea, cholera and nausea among children and adults particularly explains the disease burden associated with the foodborne diseases in the economies of underdeveloped countries. Pakistan is an underdeveloped country in which food safety and hygienic conditions have been ignored for a long time and hence, the occurrence of many pathogens in different foods is common. Estimating foodborne diseases in Pakistan is a tough job because any monitoring or infection control program is absent yet. Unhygienic processing practices and poor storage of milk, cereals, nuts and other foods are a major cause of fungus and bacterial contamination like aflatoxin and others. Foods are contaminated by heavy metals as manifested by numerous studies. Continuous increase in the population greatly affects the economy of the country that eventually degrades food materials offered for promotion to get higher profit ignoring the quality and safety regarding those products. Therefore, increasing the trend of adulteration in foods like milk poses a serious challenge for the government during the past few years. The review is a demanding topic to explain the scenario of present food safety issues in Pakistan. The review is furnished with information from local and related international researches. Therefore, it is suggested that the infrastructure of the food safety department should be redirected which ultimately helps in the hygienic supply of foods to the users.

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Introduction

With the growing world population and a lot of competition in trade, food safety issues especially in developing countries are rising (CALVIN *et al.*, 2020). Such kind of issues poses a serious threat to the sustainability as well as the economy of developing nations World Health Organization has concluded that the food-borne diseases contribute a major part in the bulk of diseases affecting the economy of developing as well as under-developed countries (Aragrande and Canali, 2020). This situation is sensitive because of very little or negligible monitoring as many cases of foodborne diseases are not even reported and remain unrecognized. This is a high issue so, as a result, most of the nations have now started uncompromising actions to control the hazards of foodborne diseases especially in the nations which are developing. These issues of food safety in the developing nations are recognized on a large scale and many international organizations are putting keen interest in it (Odeyemi *et al.*, 2019). Food security has been placed among the top 11 priorities by the prestigious World Health Organization (WHO). In this regard, WHO is making great efforts to make people aware of this devastating issue (Kafarstein and Abdussalam, 1998).

Food-borne illness has become a key challenge for developing societies as it grows up the burden of illness. It is estimated that about 2000 diarrheal episodes are occurring worldwide, 80% of which is subjected to the biological contamination of edible things which results in 3.5 million children's deaths of age up to 5 years. Biological contamination of food is also thought to be a clear reason for cholera (Fitzwater *et al.*, 2019). Infants and early aged children are mostly affected in the developing world and are the main cause of mortality in this group (Kirk *et al.*, 2017). Efforts for reducing hunger, starvation and poverty in the regions will not work until the defined approaches for food safety are improved (Garcia *et al.*, 2020). Major causative agents of diarrhea and related diseases *i.e* kidney failure include *Salmonella*, *Campylobacter*, *Listeria* and *E.coli*. Brucellosis or tuberculosis is

transmitted from animals and they affect a considerable population of the rural areas which is related to agriculture and livestock management. Water contamination, on the other hand, results in various kinds of infections in the intestine and other severe complications afflicting millions of people (Riley, 2020).

Aflatoxins (Shapiro, 2019), heavy metals, pesticide residues (Hu *et al.*, 2019) and various adulterants are included in the food chain supply and create a disaster to the health of a lot of people in Pakistan because of the definite and poor control and monitoring. Such hazards are increasing the risk of cancer and other fatal diseases in humans (Imtiaz *et al.*, 2020). Likewise, excessive and unauthorized use of antibiotics for the treatment of animals has claimed to increase the resistance of microorganisms against these antibiotics (Mohsin *et al.*, 2019). Current food safety issues and its consequences are highlighted in this paper for the health and economic issues of Pakistan. This review provides a better understanding of food security issues at national as well as international levels. Scientific research regarding food safety in Pakistan is limited, therefore, it is the need of the hour to make healthy literature on this topic as this will work to explain the discussed issue. The figures included in this paper and the statistics are derived from international and local researches which were done to evaluate the amount of the various food contaminants in different regions of Pakistan during the last few decades.

Pesticide residues

Pesticide residues come under chemical hazards according to hazard analysis and a critical control point (HACCP). Continuous usage of pesticides and their worse impact on different life forms results in significant issues with food safety leading to human health. The pesticide residues in organics indulge in drinking water and food chain ultimately get mixed in the human bloodstream. Although there are potential hazards and risks regarding usage of these pesticides and the doses used which resulted in the increment of issues in Pakistan. Unquestionably, the yield of

various crops is improved at a significant rate by applying pesticides and yield loss is controlled by insect pests. Moreover, diseases caused by the indigestion of residual pesticides have resulted in a serious discussion (Zia *et al.*, 2009; Ahmed *et al.*, 2011;) narrated the injudicious use of pesticides in cropping field and its good and bad impacts on the environment.

Despite the increased production and processing cost related to the wide-scale use of pesticides, they are still used very often. However, unnecessary and excess usage of pesticides significantly resulted in a higher comparative accumulation of residues in vegetables which are ultimately being consumed by humans (Grewal *et al.*, 2017; Mebdoua, 2018). The important physicochemical characteristics which examine the degree of accumulation of the pesticide's residues in various food items are water octanol partition coefficient, volatility, hydrolytic rate constants and solubility, etc (Lushchak *et al.*, 2018; Gallo, 2019). Because of the recent researches in the field of science and switching of print media to the most advanced electronic media, people have become more aware by witnessing among different groups of consumers on the health hazards issues about pesticide residues. Nations in the world are getting aware of the pesticides' effects on the health of human beings. (Alananbeh and Hayajneh, 2019). Substantial levels of pesticide residues in a foodstuff have been verified in many studies in Pakistan. In various parts of Punjab and Sindh, underground water has been polluted widely (Syed *et al.*, 2014).

The over-growing use of pesticides is polluting the underground drinking water thus posing serious threats to consumers. The workers in the cotton field are prone to serious health risks and become victims of haphazard use of pesticides.

Proper documentation, monitoring and reliable reporting are needed to control the damaging impact of pesticides. Another logical approach to reducing the health issues caused by pesticides is adherence to environmental laws and policies (Damalas&

Eleftherohorinos, 2011; Narendran *et al.*, 2020). Open wells in the rural areas of D.G Khan, Bahawalnagar, Rajanpur and Muzaffargarh districts of Punjab, Pakistan are badly contaminated with six common pesticides *i.e.* carbofuran (59.4%), cyhalothrin (5.4), Bifenthrin (13.5), monocrotophosendosulfan (8%) and methyl parathion (5.4%) thus indicating serious health risk for the residents. Likewise, high levels of pesticide residues have been found in 61% of the total tested vegetable samples *i.e.* eight vegetables including cauliflower, tomato, eggplant, spinach, green chilli, bittergourd, peas and apple gourd) exceeding the maximum recommended limits (MRLs) (Tariq *et al.*, 2004; Ahmed *et al.*, 2011;). As the fruits and vegetables constitute a major part of the diet in Pakistan therefore the contaminated fruits and vegetables affect the health of consumers badly. Apart from the sound safety and hygiene care in Islamabad, dimethoate is highly found in some edible fruits and vegetables such as bringal (0.004 mg/kg), cauliflower (1.80 mg/kg), apple (0.032 mg/kg), taro root (0.13 mg/kg), banana (0.004 mg/kg) and chlorpyrifos found in brinjal (0.004 mg/kg) and fenvalerate was found in apple (0.010 mg/kg). Moreover, these pesticide amounts exceeded the maximum recommended limits (MRLs) (Tahir *et al.*, 2001).

Heavy metals

Increasing population and industrialization throughout the world prevails as two most annoying factors, simultaneously, changing the lifestyle of human being with the disclosure of food safety and security issues especially in Pakistan. Agriculture is the principal source of living for the main percentage of population living in Pakistan. The agricultural soils are greatly contaminated with heavy metals in the worst manner and hence polluting the atmosphere with copper (Cu), cadmium (Cd), lead (Pb), and zinc (Zn) (Alam *et al.*, 2020). Heavy metals released from industries and automobiles deposit on the surface of vegetables and fruits and become a part of the food products during packaging and processing (Bi *et al.*, 2018). Ingesting heavy metals contaminated foods which results in diminishing immunological defense,

disabilities as a result of malnutrition, intrauterine growth retardation, neurological disorders, a major occurrence of upper gastrointestinal cancer and impaired psychosocial behavior (Jaishankar *et al.*, 2014).

Contamination of heavy metals is a form of physical hazards according to HACCP. There is very little research done on heavy metals found in foods in Pakistan. Hardly any inclusive study has been conducted to estimate the widespread occurrence of heavy metals in foods. Studies with some selected vegetables and fruits in some areas of Pakistan do not accurately estimate the presence of heavy metals. A limited study revealed higher content of Ni, Zn, Cu and Pb in different vegetables and fruits being cultivated in Gilgit which is a relatively less polluted area of northern Pakistan. Coriander, Spinach and peppermint being grown in mainly Sindh Province were containing 0.90–1.20 mg/kg of arsenic consequential in total ingestion of arsenic 9.7–12.2 µg/kg body weight/day in diet (Khan *et al.*, 2010). The same type of study was carried out in Faisalabad against 210 samples which contain Cd, Pb, As, and Hg at 0.24, 2.23, 0.58 and 7.98 mg/kg levels, respectively (Iqbal *et al.*, 2017). Mango, the king of fruits in Pakistan is being served as fresh fruit in the summer and the form of different mango products throughout the whole year. Mangoes from major agricultural lands of mango growing regions (Multan, Mir PurKhas and RahimYar Khan) were tested for heavy metals content in popular mango cultivars (*Chaunsa*, *Dusahri*, *Ratol*, and *Langra*). Results revealed the increased concentrations of Cr, Ni, Cd, and Pb as compared to the acceptable limits of 1.00 mg/kg (Akhtar *et al.*, 2010). Correspondingly, another study showed the concentrations of minor heavy elements in fruits being grown in summer in Pakistan in the order as Cd<Pb<Zn<Cr<Ni<Iron (Fe) with the Fe being 14.25 mg/kg and the major elements were experimented to be in the order calcium (Ca)<sodium (Na)<magnesium (Mg)<potassium (K) with K being 409.7mg/kg. The concentration of minor heavy elements was higher than the tolerable limits laid down by the World Health Organization (Ur Rehman

et al., 2018).

Biological hazards

Mistreatment of food is a significant factor for the formation of foodborne diseases being 97% of total foodborne illness was endorsed to the improper hygiene in catering (Kamboj *et al.*, 2020). For example, fruit *chats*, street vended fruit salads in Pakistan were found to be contaminated heavily with different bacterial species like *Enterobacter* spp., *E.coli*, *Klebsiella* spp., *Salmonella* spp., *S. aureus*, and *S. Epidermidis*. Fruit *chats* displayed outside the shops for customers without cover was observed to be the worst source of contamination. *Khoya* and *burfi* are two local sweet dairy products that were tested for bacterial contamination. The occurrence of foodborne pathogens, such as *S. aureus*, *E. coli*, and *Klebsiella* spp., constituting a major part of bacterial colonies on *burfi* and *khoya* samples resulting in outbreaks that leads to the admittance of some people in hospitals (Akhtar, 2015). *E. coli* gastroenteritis, salmonellosis, typhoid, Cholera campylobacteriosis, shigellosis and brucellosis are the major known diseases caused by viruses and bacteria such as *Salmonella* spp., *Shigella* spp., *E. coli*, *Vibrio colera* and *Campylobacter jejuni*. Some protozoa species such as *Entamoeba histolytica*, *Giardia lamblia* and *Cryptosporidium* spp., and few enteric virus species such as hepatitis A, E. viruses, rotaviruses and calciviruses are also found to be implied in many cases of disease-causing in developing countries. (Mendonca *et al.*, 2020). Diarrhoea, however, is the most invasive of these foods borne diseases and has emerged as a primary risk and a public health concern, particularly among infant and early aged children in Pakistan (Ahmed *et al.*, 2020).

The two most common unhygienic places are the train stations and bus stations where pulses, chickpeas carrying huge quantities of bacteria sold all around the clock. An endospore-forming Gram-positive bacteria named *Clostridium perfringens* is a major cause of gastrointestinal and histotoxic diseases, found as a contaminant in such kinds of foods (Rood *et al.*, 2018). Sweet dishes and home-prepared foods

in small communities in Pakistan were commonly contaminated with *S. aureus*, *C. perfringens*, and *Bacillus cereus* intoxication (Griffiths & Schraft, 2017; Labbe & Juneja, 2017). In another study done on commercially prepared ice-cream has shown that a high percentage of tested samples were found to be contaminated with *Enterobacter aerogenes* (34%), *Proteus spp.*, (16%), *S. aureus* (26%), *B. cereus* (4%), *Citrobacter spp.* (10%) and *Streptococcus (St.) faecalis* (12%) thus confirming that the ice-cream prepared on a commercial scale is not safe for human consumption (Series, 2019). A similar type of study was carried out in Gilgit town and Lahore which shows various enteric microorganisms in samples like *E.coli*, *Proteus*, *Salmonella*, *Satphylococcus* (Ahmed *et al.*, 2009; Sarwar *et al.*, 2018). *Campylobacter* infections are allied with abdominal pain and dysentery. Studies pointed out a higher prevalence of *Campylobacters* as potential threats in meat and milk samples in Pakistan (Nisar *et al.*, 2018). One study confirmed *Campylobacters* to be present in 48% of the total (1636) tested samples of meats and milk and 40.9% of vegetables in three major cities of Pakistan. Shigellosis is another potential health threat in Pakistan and has been rapidly rising as a more severe illness than *Campylobacter* infections. *Shigella spp.* has been shown to increase resistance and is generally thought to be a major cause of foodborne diseases. Shigellosis is mostly linked with poor sanitary conditions, unsafe drinking water, and unavailability of normal healthcare facilities. Hence, this infection is known as the disease of the poor in Pakistan (Jamal *et al.*, 2020). Wide arrays of vegetables are regularly consumed in Pakistan and serve as a rich source of vitamins, minerals, bioactive compounds, and fiber. *Listeria monocytogenes* are commonly present in many raw and minimally processed vegetables, thus more care has to be exercised to benefit from their nutritional value (Kljujev *et al.*, 2018).

Aflatoxins

Human health is affected by many toxins, more importantly, potent mutagenic, teratogenic and carcinogenic metabolites produced by *Aspergillus flavus* (B1 and B2) and *A. parasiticus* (G1 & G2),

toxins produced by the fungus, M1 (a metabolite of aflatoxin B1 in humans and animals) and M2 (a metabolite of aflatoxin B2 in the milk of cattle fed on contaminated food) are the most potential threats for human health (Dhakal and Sbar, 2020; Nazhand *et al.*, 2020). Due to the warm and humid climate, in Pakistan, foods are more prone to aflatoxin contamination and this situation is aggravated by malpractices held during storage and handling of edibles (Akbar *et al.*, 2020). Aflatoxin contamination is considered to be linked with various types of cancer most importantly the liver cancer among the population of the biggest city of Pakistan named Karachi (Hamid *et al.*, 2013). As 10% and 17%, aflatoxin contamination was reported in different parts of Karachi. Pakistan ranks as the sixth-largest exporter of chili peppers, contributing 1.5% of GDP (Abrar *et al.*, 2009).

Chillies are susceptible to aflatoxin contamination, and it presents a potential risk to human health. To eradicate these strains a more intense and dedicated approach is needed. Many studies reported levels of aflatoxin, eight-fold higher than EU permissible limits (Khan *et al.*, 2014; Asghar and Zahir *et al.*, 2016).

In Pakistan, the concentration of these aflatoxins detected in chili caused severe health issues to consumers. Therefore, more sophisticated and appropriate handling is required at pre-harvest and post-harvest stages. Other edibles that are prone to contain aflatoxins include beans and cereals (Lutfullah and Hussain, 2012; Asghar *et al.*, 2017). 15-45 % of polluted samples of broken rice, maize, wheat, barley, and sorghum contains the highest concentration (15.5 $\mu\text{g}/\text{kg}$), however, in wheat samples; this limit is higher than other limits (4 $\mu\text{g}/\text{kg}$), as directed by the European Union (EU) regulations. Similarly, Northwest Frontier Province of Pakistan and other rural localities tested for aflatoxins, found to contain from undetected to 30.92 $\mu\text{g}/\text{kg}$. In a separate study conducted to check aflatoxins concentration shows that in 70% of rice samples, these concentrations reach up to a mean concentration of 4.9 mg/g (Majeed *et al.*, 2013;

Asghar and Ahmed *et al.*, 2016; Wajihul Hassan *et al.*, 2020).

Health concerns of aflatoxins ingestion through foods have been extensively discussed in the literature under the field of food safety. Due to high sickness levels and low productivity, developing countries are still facing this challenge that has been adversely affecting the health and economy of these countries. Other measures responsible for this aflatoxins prevalence in various commodities include public health interventions for efficient production, processing, and storage, absence of decontamination techniques at home and commercial level. Lack of awareness and strict legislation are also some of the probable reasons for this contamination. To counter this issue, intense care must be exercised at all levels of food safety. In this situation, to eradicate or lessen health risks, technology like smartphone apps, monitoring and supportable health programs, testing and other analytical facilities should be put into practice (Pan, 2020; Udomkun and Njukwe, 2020). In Pakistan, food security and safety are two observable contributing factors, preventing the national economic growth through disease burden among the population. To account for the prevalence of these toxins through food, various efforts have been made over the past few decades (Ismail *et al.*, 2020). The current information derived through various studies may not completely reflect the severity of damage done by the aflatoxin's ingestion through edibles.

Adulterants

One of the serious problems recognized worldwide is food adulteration. Underdeveloped countries, mostly prefer inferior quality ingredients to enhance their profit and sale. These low-cost ingredients in return pose injurious effects to human health. This problem seems to be prevailing in the Indian subcontinent, relatively more affecting the average family consuming the goods mixed with harmful substances and chemicals such as dyes, soapstone and sawdust. Similarly, bakery products, beverages, tea, sweets, bottled milk, oil and ghee are largely consumed in

Pakistan (Choudhary *et al.*, 2020). Among other adulteration, adulteration of milk is one of the most common types of adulteration in Pakistan and 75% of the total milk sold in tetra packs or the loose form is adulterated. Ingredients of these products include hydrogen peroxide carbonates, bicarbonates, caustic soda, antibiotics, and formalin (Arif *et al.*, 2020). Adulteration of milk leads to inferior quality with more toxic compounds and negligible nutritive value. In Pakistan, drugs observed in milk are a potential risk to human health. Besides this, hair urea and powders used for hair removal have been reported to be used as ingredients to provide the milky feel of cosmetics (Latif *et al.*, 2011). Similarly, to evaluate the nutritional value and composition, a study was conducted. The consequence of this study showed that these 82 milk samples didn't meet the required standard as the presence of 12 different metals was detected in 19 different imported brands of milk in Karachi (Alamgir *et al.*, 2018; Barham *et al.*, 2018).

Climate change

Pakistan economy based upon agriculture and most of its food and GDP growth come in house by agricultural products but due to the adverse changing in the climate it is under a lot of pressure like shortage of water for irrigation and rising temperature pose a threat to the Country's food security and safety as certain fodder crops in Pakistan are temperature sensitive e.g. vegetable, rice, cereals and other grains (Menhas *et al.*, 2016). Climate change also affects food products as it encourages various bacterial and viral infections in the crops. Climate change effects feed productivity and nutritional level which ultimately poses dire impacts on animal food production diminishing its nutritional capabilities. Likewise, in ocean food production, climate change increases the CO₂ level in the ocean which alters ocean acidity and poses ramifications on ocean production (FAO, 2010). Climate change intricately disturbs rainfall patterns along with the absorption of nutrients from the soil causing adverse effects on the nutritional levels of the food, ultimately changing the nutritional diversity in the food commodities which promotes trans-generational

malnutrition cycles (Fanzo *et al.*, 2018). The global climate change also impacts crop-livestock mixed culture in adverse manners. In a study, it has been seen that with an increase in the 1°C in temperature global yield of the food crops will diminish e.g. wheat by 6%, maize by 7.4% and soybean by 3.1% (Ahmad and Ma, 2020). With the changing climate, there is no innovation among the local growers of Pakistan in adopting new techniques that should be addressed at the national level to make a positive impact on the food safety (Ahmad *et al.*, 2016).

Conclusion

The present situation of food safety in Pakistan has become a burning issue adversely affecting the economy of the state. Strict and timely measures are needed to be taken to secure the nation's economic infrastructure. Continuous increase in the prevalence of food-borne illness and diseases especially diarrhea among children has led to an alarming situation of food insecurity as the future of the country relies upon a healthier nation. Therefore, food security issues are needed to be addressed scientifically in Pakistan. It is clear from the evidence that the foods in Pakistan are largely contaminated with pesticide residues, heavy metals and adulterants posing serious threats to human health and well-being.

There is an urgent need for a strong consumer protection society, food hygiene training, food safety awareness, right to avail safe food, strict obedience of food security laws and the making of new laws to change food safety perspective. A practical and systematic step is the appreciation of this challenging issue by the stakeholders that are more effective to curtail the risk of chemically and microbiologically borne diseases and to diminish the health risks associated with utilization of unsafe food in Pakistan.

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